Claims:

1. A method for manufacturing an avalanche photodiode suitable for single photon detection applications, comprising forming upon a substrate the layers comprising at least:

an absorption layer defining a tunneling onset field;

at least one intermediate-bandgap transition layer;

a field control layer;

a multiplication layer defining a breakdown electric field;

wherein said field control layer is configured so as to generate one of:

i. an electric field reduction therein comparable to said breakdown electric field; and,

ii. an electric field reduction therein that, together with an electric field reduction in said multiplication layer, provides a total field reduction comparable to said breakdown electric field.

2. The method according to claim 1, wherein said field control layer is made with a dopant concentration designed to provide said electric field reduction similar to said breakdown electric field plus or minus half of the tunneling onset field of the absorption layer.

3. The method according to claim 2, wherein said absorption layer is made to provide tunneling onset field of up to 20V/μm.

4. The method according to claim 2, wherein said absorption layer is made to provide tunneling onset field of about 5-10V/μm.

5. The method according to claim 1, wherein said field control layer comprises a doped InP.

6. The method according to claim 1, wherein said multiplication layer is made to define a ratio of hole to electron ionization constants of about one.

7. The method according to claim 6, wherein said multiplication layer is made to comprise InP.

8. The method according to claim 1, wherein said multiplication layer is made to define a ratio of hole to electron ionization constants of between about 0.7 and 1.3.

9. The method according to claim 8, wherein said multiplication layer is made to comprise $Ga_xIn_{1-x}As_yP_{1-y}$.

10. The method according to claim 8, wherein said multiplication layer comprises $Ga_{0.18}In_{0.82}As_{0.39}P_{0.61}$.

11. The method according to claim 1, wherein:

said absorption layer is made to comprise one of InGaAs and InGaAsP;

said intermediate-bandgap transition layer is made to comprise $Ga_xIn_{1-x}As_yP_{1-y}$

said field control layer is made to comprise *n*-InP; and

said multiplication layer is made to comprise *i*-InP.

12. The method according to claim 11, wherein said intermediate bandgap layer is made to comprise three grading layers of the formula $Ga_xIn_{1-x}As_yP_{1-y}$ and having λ_c = 1.1, 1.3, and 1.5 μm, respectively.

13. The method according to claim 11, wherein said absorption layer is made to comprise a first absorber comprising one of *i*-InGaAs and *i*-InGaAsP, and a second absorber comprising one of *n*-InGaAs and *n*-InGaAsP.

14. The method according to claim 1, wherein said field control layer is made by selecting a thickness, t, and a doping level, ρ, satisfying the relationship:

$$\rho\, t = (\varepsilon/e^-)(E_{bd} \pm (1/2)E_{TC} - \Delta E_{ML});$$

where ε is the dielectric constant of the material said field control layer is made of; E_{bd} is said breakdown field; E_{TC} is a tunneling current limit field in said absorption

layer; ΔE_{ML} is field drop over said multiplication layer and has a value between zero and E_{bd}.

15. The method of claim 1, wherein said avalanche photodiode is made in an etched-mesa form.

16. The method of claim 1, wherein said avalanche photodiode is made in a bulk-planer form.

17. The method according to claim 1, wherein said multiplication layer is made to provide jitter of less than 65ps.

18. The method according to claim 5, wherein doping of said control layer is selected in the range of $2.5*10^{16}$ to $3.5*10^{18}$ cm^{-3}.

19. A method for manufacturing an avalanche photodiode designed for single photon detection applications, comprising forming upon a substrate the layers comprising at least:

an absorption layer defining a tunneling current limit field, E_{TC};

at least one intermediate-bandgap transition layer;

a field control layer and having a defined thickness, t, and a defined doping level, ρ;

a multiplication layer defining a breakdown electric field, E_{bd};

wherein said defined thickness and defined doping of said field control layer are selected so as to generate an electric field reduction therein, and wherein said multiplication layer defines a ratio of hole to electron ionization constants of between about 0.7 and 1.3.

20. The method according to claim 19, wherein said defined thickness and defined doping of said field control layer are selected so as to generate one of:

i. an electric field reduction therein sufficient to maintain said tunneling current limit field below the tunneling offset limit; and,

ii. an electric field reduction therein that, together with an electric field reduction in said multiplication layer, provides a total field reduction sufficient to maintain said tunneling current limit field below the tunneling offset limit.

21. The method according to claim 19, wherein
said absorption layer comprises one of InGaAs and InGaAsP;
said intermediate-bandgap transition layer comprises $Ga_xIn_{1-x}As_yP_{1-y}$
said field control layer comprises InP; and
said multiplication layer comprises InP.

22. The method according to claim 19, wherein said intermediate bandgap layer is made to comprise three grading layers of the formula $Ga_xIn_{1-x}As_yP_{1-y}$ and having λ_c = 1.1, 1.3, and 1.5 μm, respectively.

23. The method according to claim 19, wherein said absorption layer is made to comprise a first absorber comprising one of *i*-InGaAs and *i*-InGaAsP, and a second absorber comprising one of *n*-InGaAs and *n*-InGaAsP.

24. The method according to claim 19, wherein said multiplication layer is made to comprise $Ga_xIn_{1-x}As_yP_{1-y}$.

25. The method according to claim 19, wherein said multiplication layer comprises $Ga_{0.18}In_{0.82}As_{0.39}P_{0.61}$.

26. The method according to claim 21, wherein said multiplication layer comprises $Ga_{0.18}In_{0.82}As_{0.39}P_{0.61}$.

27. The method of claim 19, wherein said avalanche photodiode is made in an etched-mesa form.

28. The method of claim 19, wherein said avalanche photodiode is made in a bulk-planer form.

29. The method according to claim 19, wherein said multiplication layer is made to provide jitter of less than 65ps.

30. The method according to claim 19, wherein doping of said control layer is selected in the range of $2.5*10^{16}$ to $3.5*10^{18}$ cm^{-3}.